Center Innovation Fund: GRC CIF

Novel Solid Polymer Nanocomposite Electrolyte to Enable Lithium Metal Safely Cycling for Next Generation High Energy Battery

Completed Technology Project (2017 - 2018)

Project Introduction

NASA future missions demand safe, high specific energy (>400 Wh/kg) batteries. Current state-of-the-art (SOA) lithium-ion batteries (LIBs) can only provide ~150-200 Wh/kg in energy capacity, which is unable to meet NASA's future energy goals, and also pose safety issues due to the use of liquid flammable electrolyte. There are intense on-going development activities to increase battery energy density. Among the promising next generation high energy battery chemistries are lithium/sulfur (Li/S) and lithium oxygen (Li/O2), in which lithium metal is used as the common anode. The use of Li metal as an anode material has emerged as one highly attractive option for achieving high-energy, next generation batteries. This is because Li has many advantages. It is the lightest metal, but also has the highest theoretical capacity (3876 mAh/g). It also has the lowest potential (0V), which boosts whole cell voltage, and Li metal is 100% active material and requires no binder. Thus, Li metal is an ideal anode material for high energy battery chemistries. However, the reliable use of this exceptionally high capacity anode in a commercial rechargeable battery has not been achieved due to safety and reliability concerns resulting from thermal runaway and short-circuit issues due to dendritic growth on the Li metal anode from lithium plating during charge-discharge cycles. The solid polymer nanocomposite electrolyte (SPNE) has been identified as a promising option to address lithium metal cycling safety. The SPNE is non-flammable and, by replacing the liquid flammable electrolyte, it eliminates leakage and fire hazard, in addition, it provides flexibility of design. This proposed solid polymer nanocomposite electrolyte addresses the challenges of achieving both high energy and safety for next generation battery. However, the SPNE technology must be developed to possess high conductivity, and thermal and mechanical properties conducive to robust Li metal cycling safely. The goal is to maximize ionic conductivity, thermal and mechanical properties of the solid polymer nanocomposite electrolyte (SNPE) film by optimizing compositions, and identify the maximum current density for depressing Li dendrites for safe Li cycling.

Anticipated Benefits

This innovation is very promising for developing advanced battery with both high energy and safety to meet energy requirements of NASA future missions. NASA's future HEOMD, SMD, and ARMD missions demand safe and high energy density batteries. NASA's Space Power and Energy Storage Road Map identifies the need for 2-3x higher energy density than currently available. Current LIB energy density (<250 Wh/Kg) is not sufficient for the next generation of electrochemical energy storage needs (>400 Wh/kg). Lithium metal based advanced battery chemistries are envisioned to be mission enhancing and mission enabling for future space and aeronautic applications. Technological advancement in energy storage will lead to smaller, lighter and higher energy storage systems that are needed for aerospace/space

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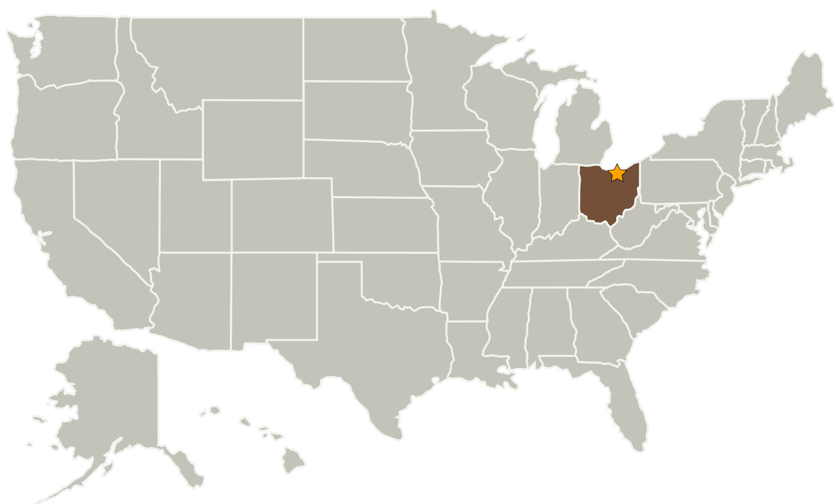
applications. Safety and reliability will become a large concern as the system energy storage increases. Risk for fire and explosion increases as the energy capacity increases. The failure modes and mitigations for hazards associated with these failures will also change and evolve.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Glenn Research Center(GRC)	Lead Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations
Ohio

Project Transitions

October 2017: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Glenn Research Center (GRC)

Responsible Program:

Center Innovation Fund: GRC CIF

Project Management

Program Director:

Michael R Lapointe

Program Managers:

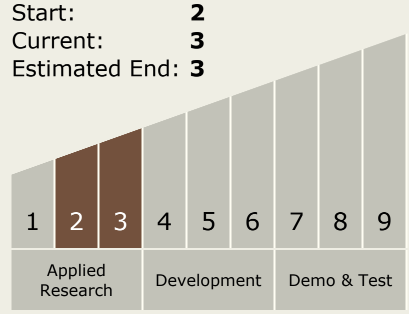
Kurt R Sacksteder
Gary A Horsham

Principal Investigator:

James J Wu

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



September 2018: Closed out

Closeout Summary: This project proved that this novel solid polymer nanocom posite (SPNE) has improved ionic conductivity which is equivalent and similar to liquid electrolyte and enables Li metal to safely cycle. It can carry current densit y up to 20 mA/cm2 and extend to high temperature (up to 300 C). The current maturity is TRL 3. The primary goal of the project was to maximize ionic conduc tivity, and further minimize interfacial resistance and widen the electrochemical voltage window by optimizing components and formulations.

Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VC

Technology Areas

Primary:

- TX03 Aerospace Power and Energy Storage
  - └ TX03.2 Energy Storage
    - └ TX03.2.1 Electrochemical: Batteries

Target Destinations

Earth, The Moon, Mars